EXHIBIT T

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results have been quite gratifying and have led to the conclusion that the cleaning of stone ballasted tracks is justified where only one cubic yard of stone may be conserved in a distance of 8.1 lineal feet of double track; that is, one cubic yard of material saved in this distance justifies the employment of the necessary labor to screen it out. In the cleaning of several miles of freight tracks formerly ballasted with stone, it has been amazing to see the amount of stone so saved. Tracks that had deteriorated by the presence of dirt and cinders in the voids of the stone ballast were restored to a condition that had formerly been obtained only by the wholesale removal of the material from the tie cribs; loading and taking it away as waste, an extravagance that has been overcome by the use of screens.

The employment of ballast screens has been found economical in the "out of face" cleaning of single tracks and multiple track and in yards; also in combining the cleaning with tie renewals. As an example of the saving effected, an organization consisting of 12 men, one foreman and one water boy cleaned 200 lineal feet of standard ballasted double tracks per 10-hour day where tracks were 12 ft. centers, using 3 screens, one on either side and one in the center between tracks. The ballast was cleaned 12 in. below the bottom of the tie on the berme, 6 in. below the bottom of the tie in the center ditch and level with the bottom of the tie in the cribs. It amounted to the handling of 104 cu. yd. of stone in the 200 ft. stretch per day. The unit costs of this progress were arrived at as follows:

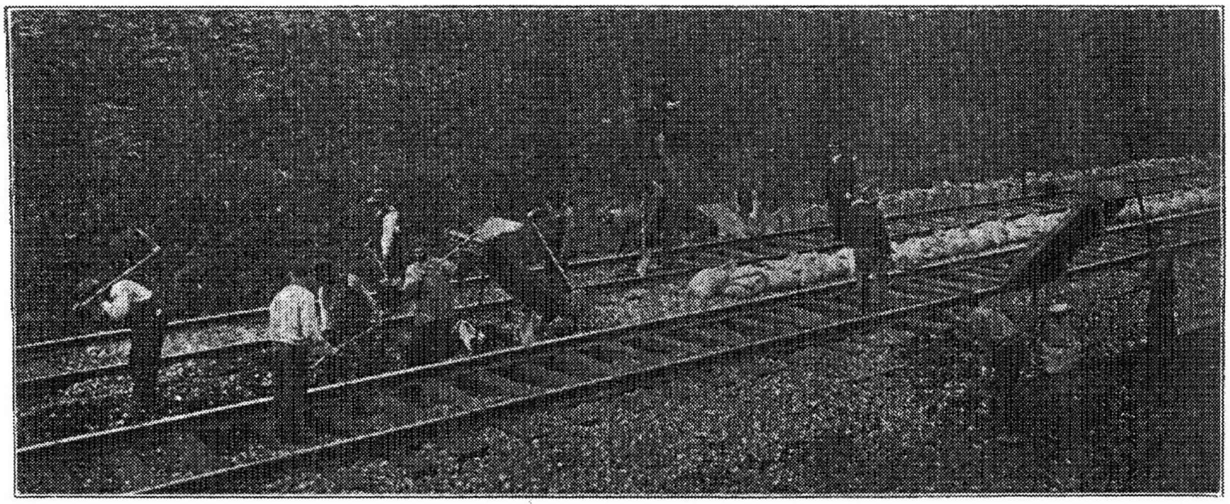
Length of double track cleaned per day, lin. ft.	200
Cubic yards stone cleaned per day	104
1 foreman at $77 per month.	
1 water boy at 15c. per hour.	
12 laborers at 15c. per hour.	
Total cost per day	$22.46
Total cost per lin. ft. double track	0.112
Total cost per cu. yd. ballast	0.216

The ballast yielded 400 wheelbarrow loads of dirt per 100 lin. ft. of track, representing approximately 50 per cent of the volume of the stone. The voids in the stone amounted to 40 per cent, so that the loss of volume in cleaning amounted to 10 per cent. To determine the extent to which the material conserved justifies cleaning ballast we have the following:

Cu. yd. dirty ballast handled	Percentage of total volume		Total cost cleaning	Cost per cu. yd. stone saved	Cost per cu. yd. new stone unloaded on track
	Stone	Dirt			
104	100	40	$22.46	0.216	1.00
104	90	50	22.46	0.24	1.00
104	80	60	22.46	0.27	1.00
104	70	70	22.46	0.31	1.00
104	60	80	22.46	0.36	1.00
104	50	90	22.46	0.43	1.00
104	40	100	22.46	0.54	1.00
104	30	110	22.46	0.72	1.00
104	21.5	118.5	22.46	1.00	1.00
104	20	120	22.46	1.08	1.00

When only 21.5 per cent of the total volume of material handled passes over the screen and is saved for re-use, the screening operation becomes as expensive as the application of new stone. In other words, 21.5 per cent of the volume per lineal foot of double track represents the amount of stone which must be saved in order that screening be economical, which is equivalent to the conservation of only 1 cu. yd. in 8.1 lin. ft. of double track.

Aside from this very important economy, the practice of screening ballast instead of putting the track up on new ballast admits of maintaining surface without disturbing the roadbed under the ties, a factor of vital importance in ideal track maintenance. It has the advantage of being quicker and more thorough than the fork method; laborers do not tire as quickly under it, and with the screens arranged as described the invariable tendency is for the men to compete with each other for speed.



Cleaning Stone Ballast with Screens

CHARACTERISTICS OF SLAG AND CHAT BALLAST

By P. H. Hamilton

Roadmaster, St. Louis & San Francisco, Memphis, Tenn.

All trackmen agree that crushed limestone makes the best ballast under any traffic, or in any locality. However, a large per cent of the railroads in the United States are not so situated that they can secure limestone ballast, or are not financially able to purchase or to produce it. Consequently they are forced to use the best natural ballast available and the refuse, or by-products, from other industries are often utilized.

Slag is used extensively by roads entering the great iron and steel producing centers, some of them transporting it hundreds of miles. Slag is the residue stone from blast furnaces, and pig iron smelters produce the best slag. There are many classes and varieties, ranging from snow white to dark brown in color, some are chalky in substance and others hard as flint rock.

When the slag comes from the furnace it amalgamates, and it is necessary to blast it loose before loading. That used for ballast is seldom classified or screened, most roads or contractors loading it directly onto ballast cars with steam shovels. Consequently there is great variation in the size of the particles. The larger per cent runs from 1/2 in. to 2 in. in diameter; but in a car of fine slag we find many pieces larger than a water bucket, which often cause trouble in unloading. Sometimes they block the opening in the bottom of the car. When a drag tie is being used for leveling the ballast these pieces frequently catch on the track and derail the car being unloaded. Where the ties have been properly spaced previous

to unloading slag these larger pieces often drag on the ties, bunching them and making respacing necessary. These larger pieces may be broken up by hand, but it is more often necessary to discard them when applying the ballast.

The darker slag, called glassy slag, breaks into small particles of prismic form, ranging from ½ in. to 2 in. in diameter, and is considered the best slag for ballast. The white, or grey slag, is lighter in weight. Some of it resembles limestone, and sometimes it resembles coral and breaks up very easily when being tamped. That which resembles limestone makes good ballast, but it is not uniform in size and generally contains a large percentage from 2 to 6 in. in diameter. Sometimes these larger pieces can be broken with spike mauls or tamping picks, but more often it is necessary to lay them to one side and finally to move them to some place where they can be used for bank protection.

While it is not the general practice to classify slag for ballast, I believe that it should be done as it is loaded, and all pieces too large for the purpose should be run through a crusher, or discarded at the pit.

Slag ballasted track can be worked at any time of the year. It drains well and it is practically dustless. It will keep down the growth of vegetation, but it should be cleaned as often as limestone ballast. This is especially necessary on heavy grades where there is an accumulation of engine sand and front-end cinders. Where the embankments are sodded with Bermuda grass the only way to keep this grass out of the ballast is to clean it every two years. Slag has been objected to on account of being chemically injurious to the rails and ties, but this effect is not noticeable. When unloading slag a faint gaseous odor is noticeable, and the dust causes a smarting of the eyelids. However, exposure to the air soon eliminates this chemical property. Like crushed stone, slag is hard to work, and the insertion of ties is more expensive in slag. It is applied and the track is maintained practically in the same manner as with crushed stone.

Chat ballast is used for ballast by all of the roads entering the mining districts of Missouri, Kansas, Oklahoma and Arkansas and is transported hundreds of miles. Chat is flint or ore bearing rock, broken into small angular pieces averaging ¼ in. to ½ in. in diameter. It is the refuse from the jigs at the lead and zinc mines after the mineral has been separated from the stone. It is crushed very fine to get all of the mineral out of it, and is known as tailings at the mines after it has gone over the jigs and all of the lead or zinc ore has been taken from it.

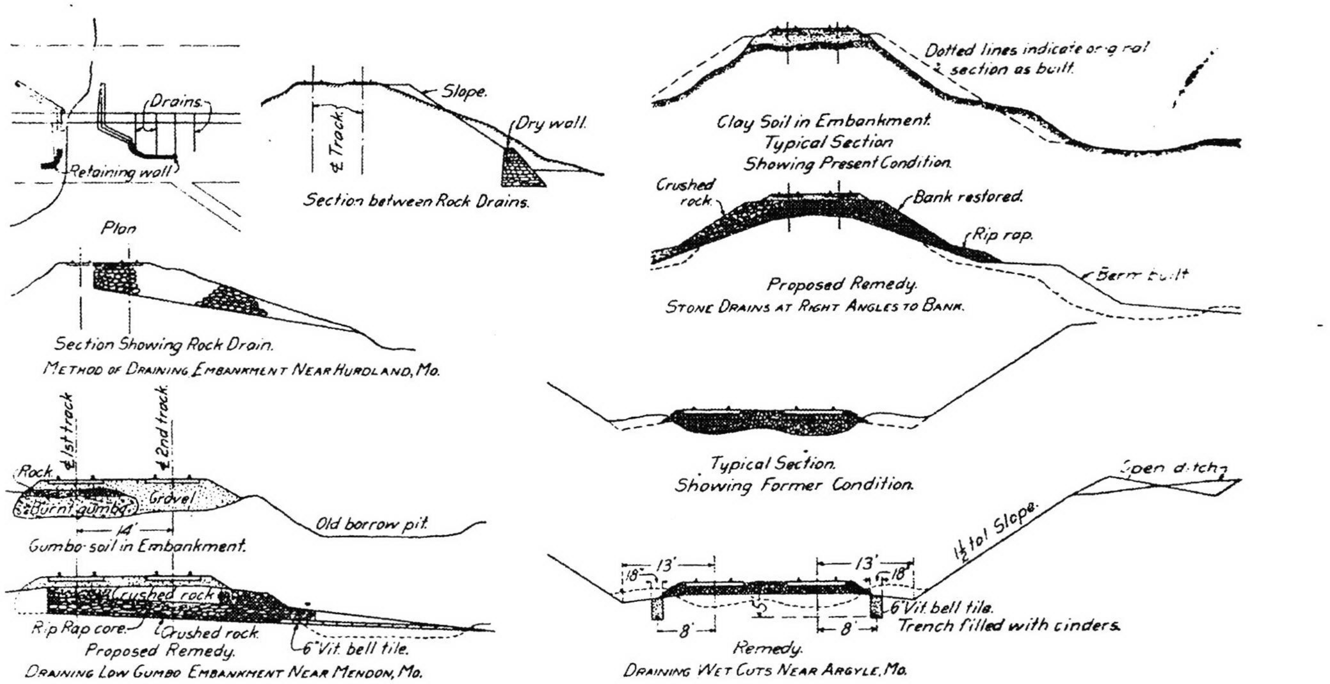
The chat is carried away from the jigs in a stream of water through a trough emptying on to a tailing pile. Sometimes the tailing trough empties into a ballast car, but more often the chat is loaded from abandoned tailing piles with steam shovels. The former method is cheap, but the stream of dirty water passing through the car is injurious to it. It also packs the ballast in the car and makes it hard to unload.

Hand jigged chat is larger than that which goes through the mills, and makes better ballast, but the quantities are limited. Chat has a good weight and is hard. It does not crumble or wear out quickly. It sheds water well, but it is necessary to have a heavy shoulder to hold the track in line, and to keep it from becoming center bound. It is easily worked, all of the tamping being done with shovels or tamping bars. Sometimes "end tampers" are used. Vegetation will not grow in it. At one time the mine owners or mill men were willing to give chats to anyone who would remove them, but now nearly all of the chat piles are controlled by contractors who lease a pile to a railroad, or furnish chat loaded on cars. It costs from 10 cents to 15 cents per cu. yd. loaded on cars.

DRAINING EMBANKMENTS IN MISSOURI

Because of the nature of the soil the railroads in northern Missouri have great difficulty in securing adequate drainage of embankments as well as of cuts. In common with other roads, the Santa Fe has given a great deal of attention to the solution of this problem, and has placed rock drains in embankments at a number of points with satisfactory results.

At one point 1½ miles west of Hurdland, Mo., water formerly collected under the ballast, causing slides in the embankment that interfered with traffic not only on the railroad but on an adjacent highway. This condition was overcome by the construction of five rock drains in the embankment extending from the



Methods of Draining Wet Cuts and Fills on the Missouri Division of the Santa Fe